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Patel et al.

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(54) **PUMP APPARATUS AND METHOD**

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F04D 29/58 (2006.01)

(52) **U.S. Cl.** **415/175**; 415/177; 415/178; 415/206

(58) **Field of Classification Search** 415/121.2, 415/175, 176, 177, 178, 179, 180, 203, 204, 415/206
See application file for complete search history.

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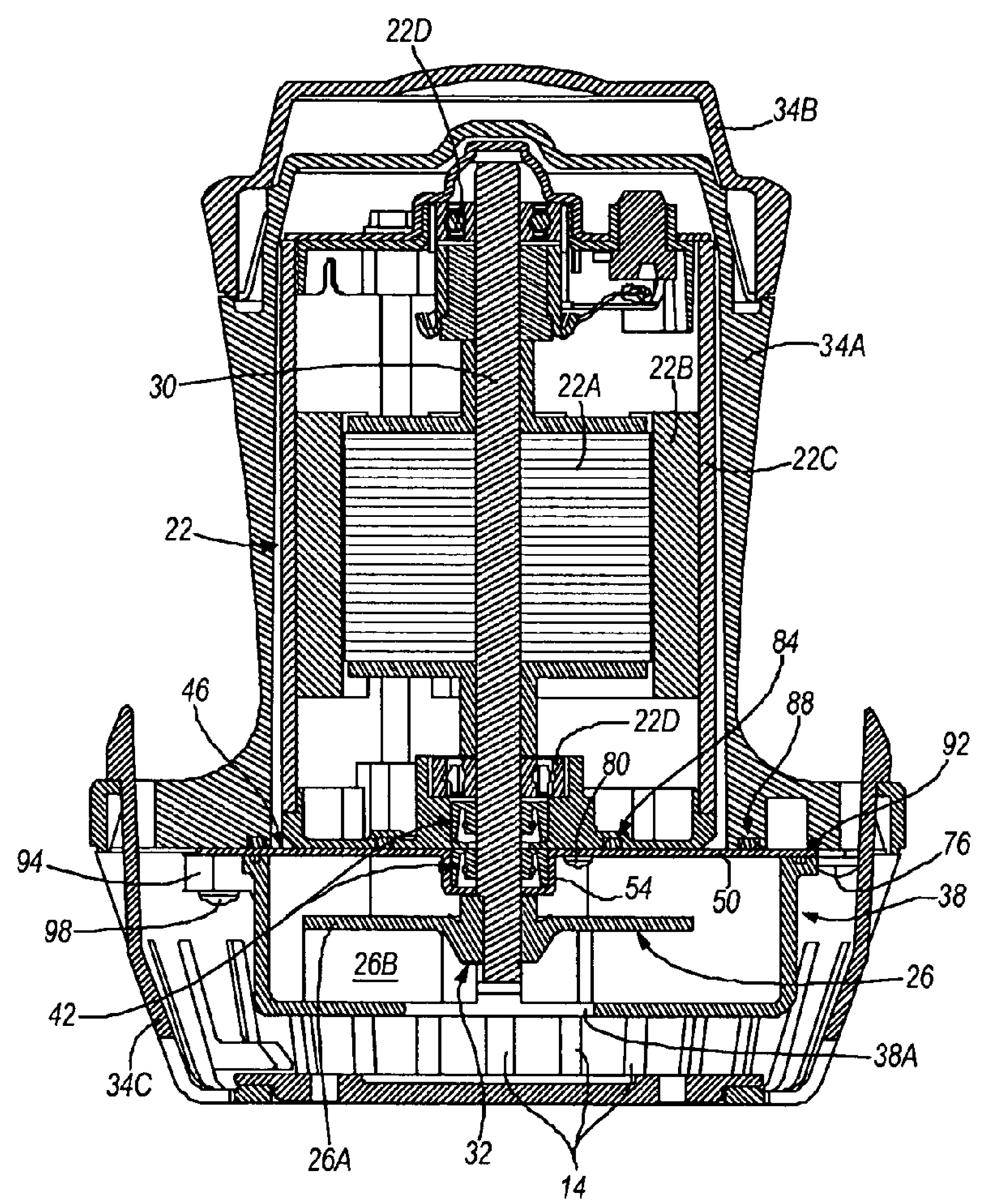
(57) **ABSTRACT**

A pump including a pump housing, a fluid inlet, a fluid outlet, a pumping chamber in fluid communication with both the fluid inlet and the fluid outlet, a motor for pumping a working fluid, and a plate that is at least partially constructed of a heat conductive material and that at least partially defines the pumping chamber. The plate can transfer heat from the motor to the working fluid in the pumping chamber.

30 Claims, 7 Drawing Sheets



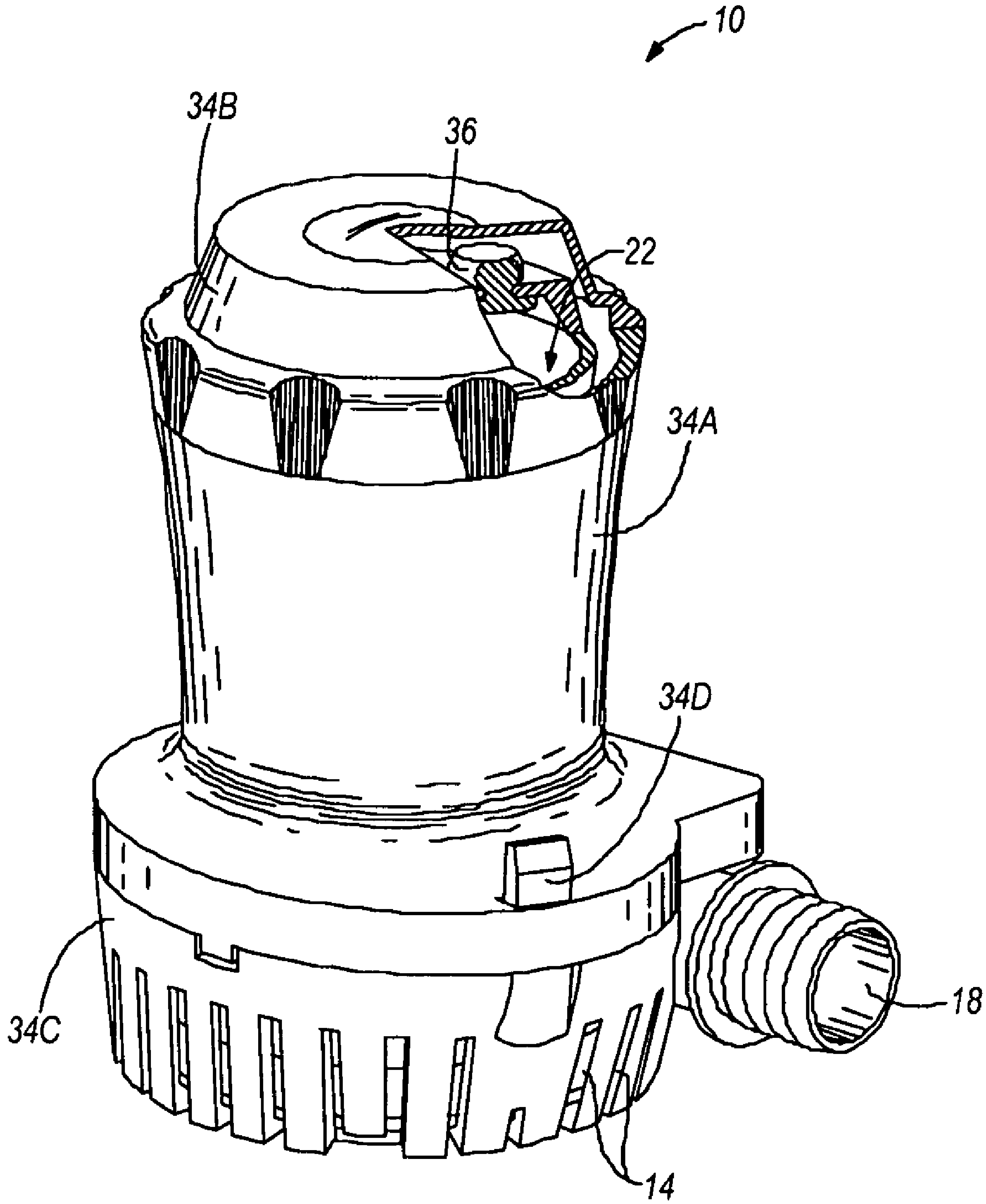


FIG. 1

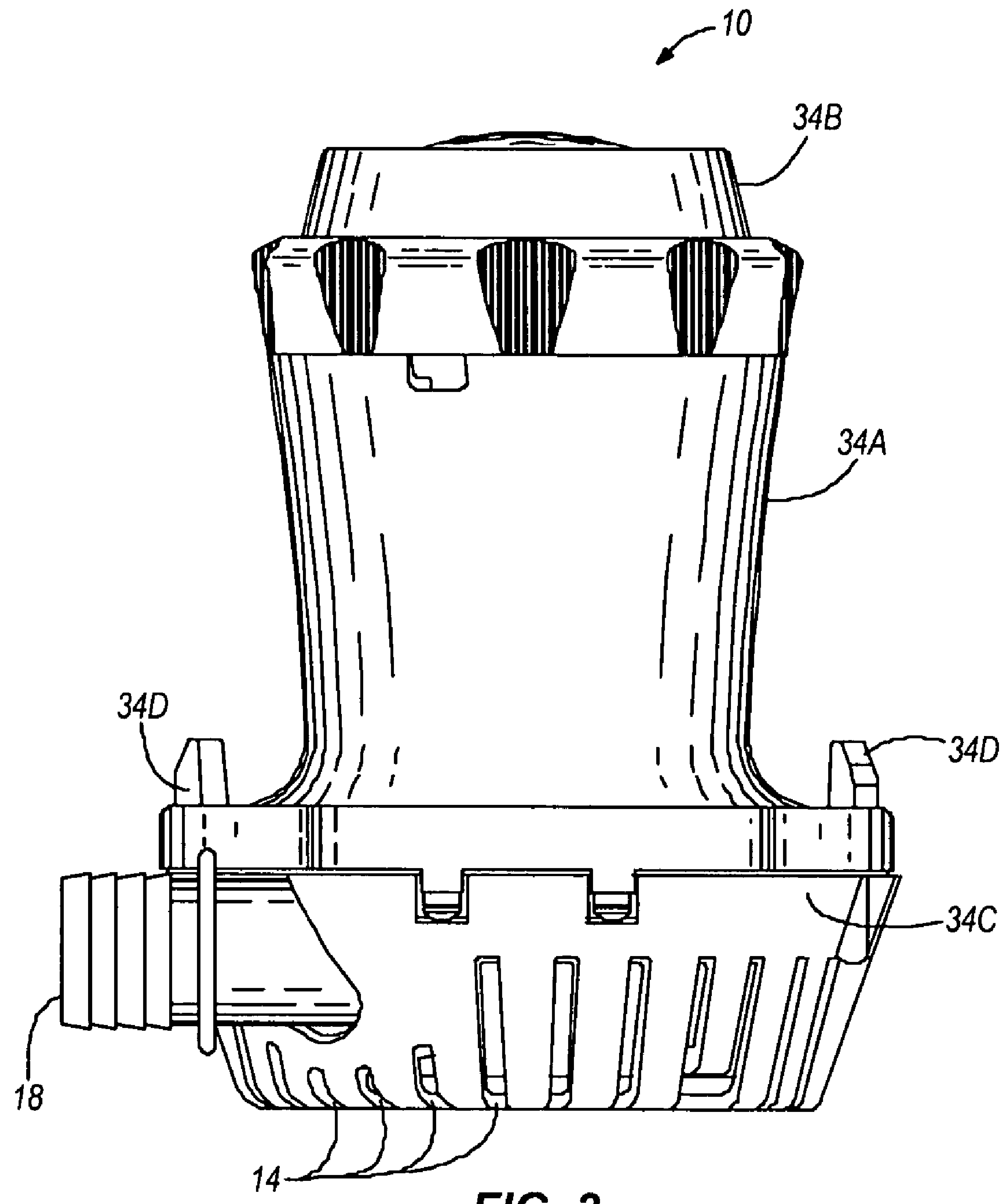


FIG. 2

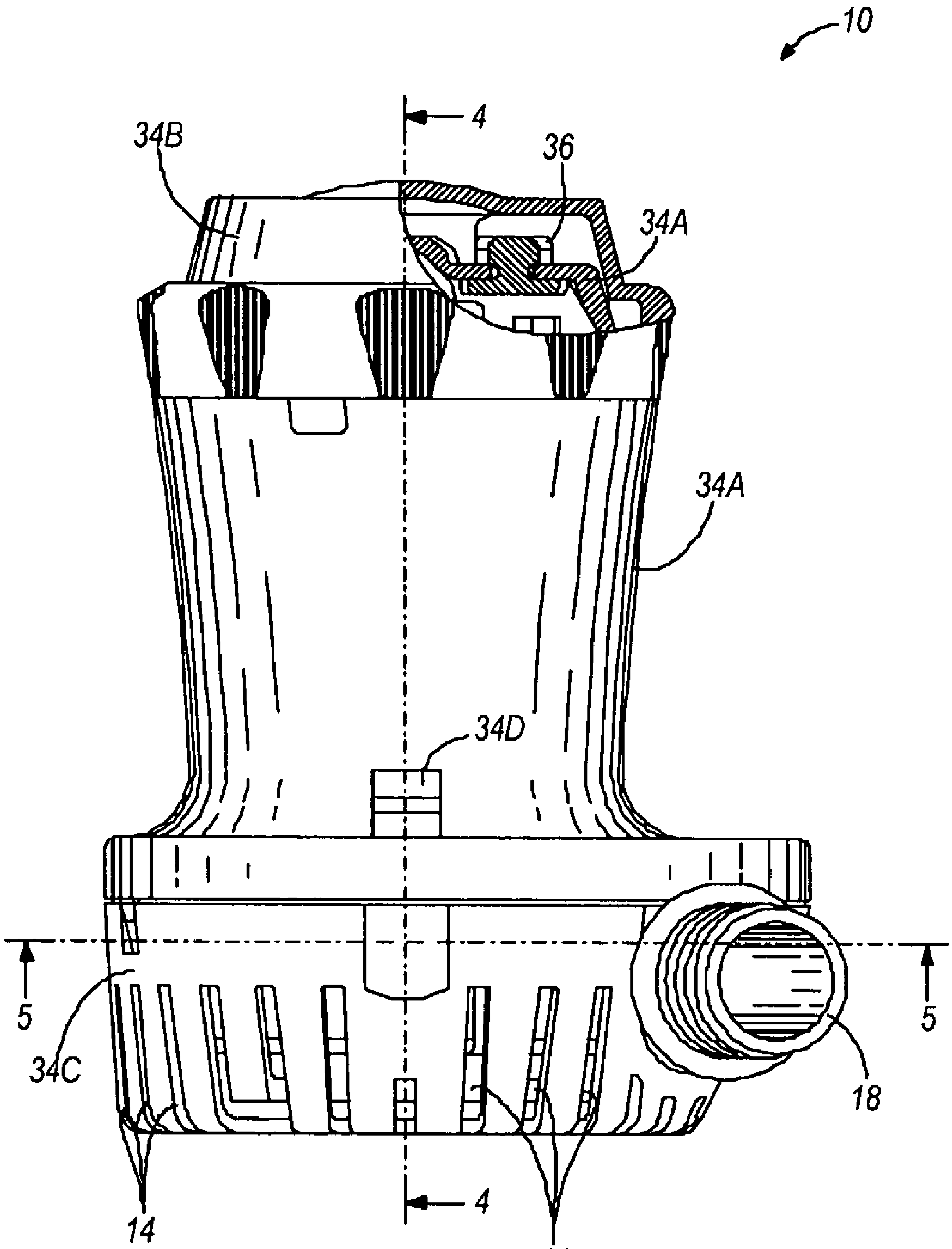
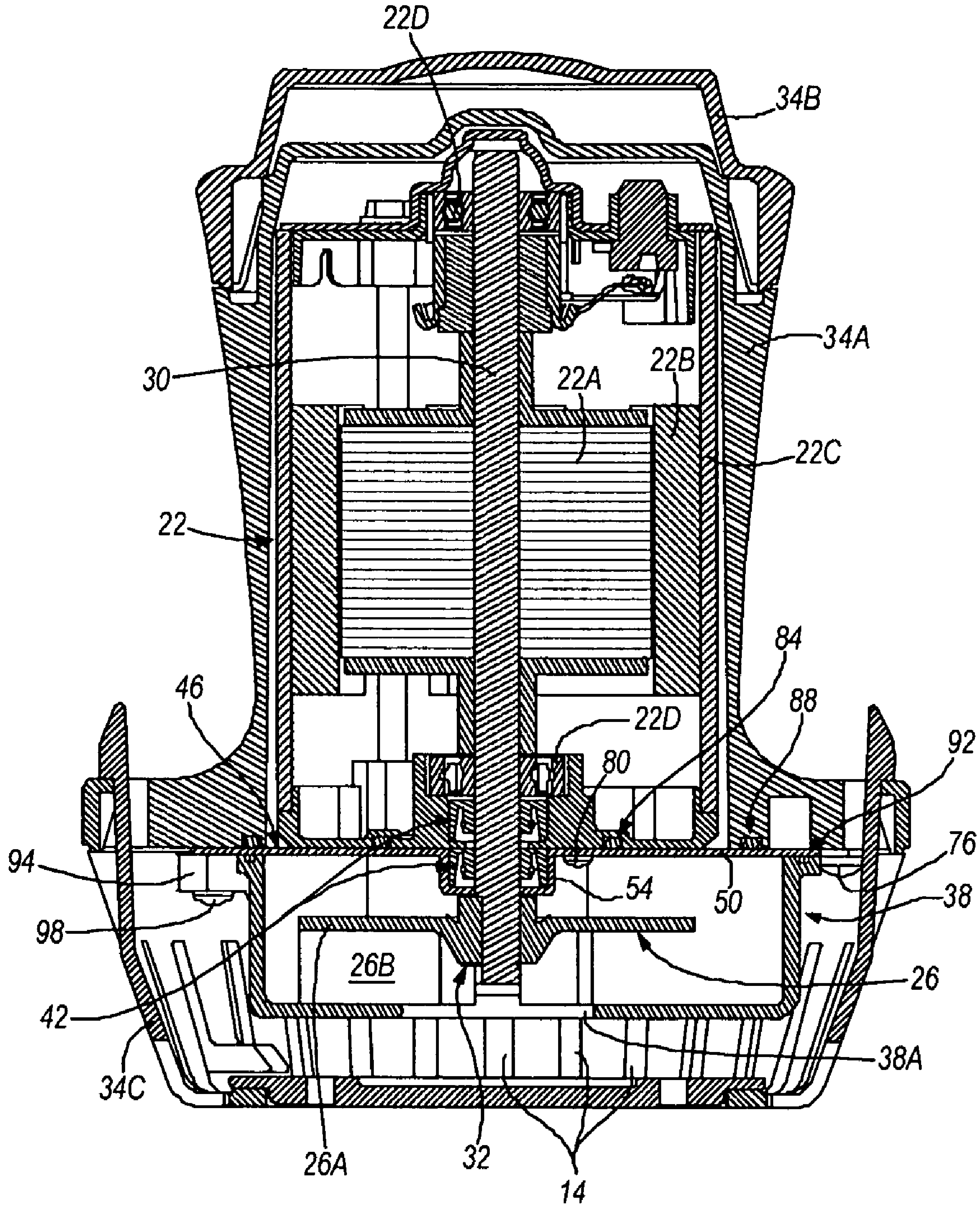


FIG. 3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34B
34A
30
22A
22B
22C
22
84
46
22D
88
92
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76
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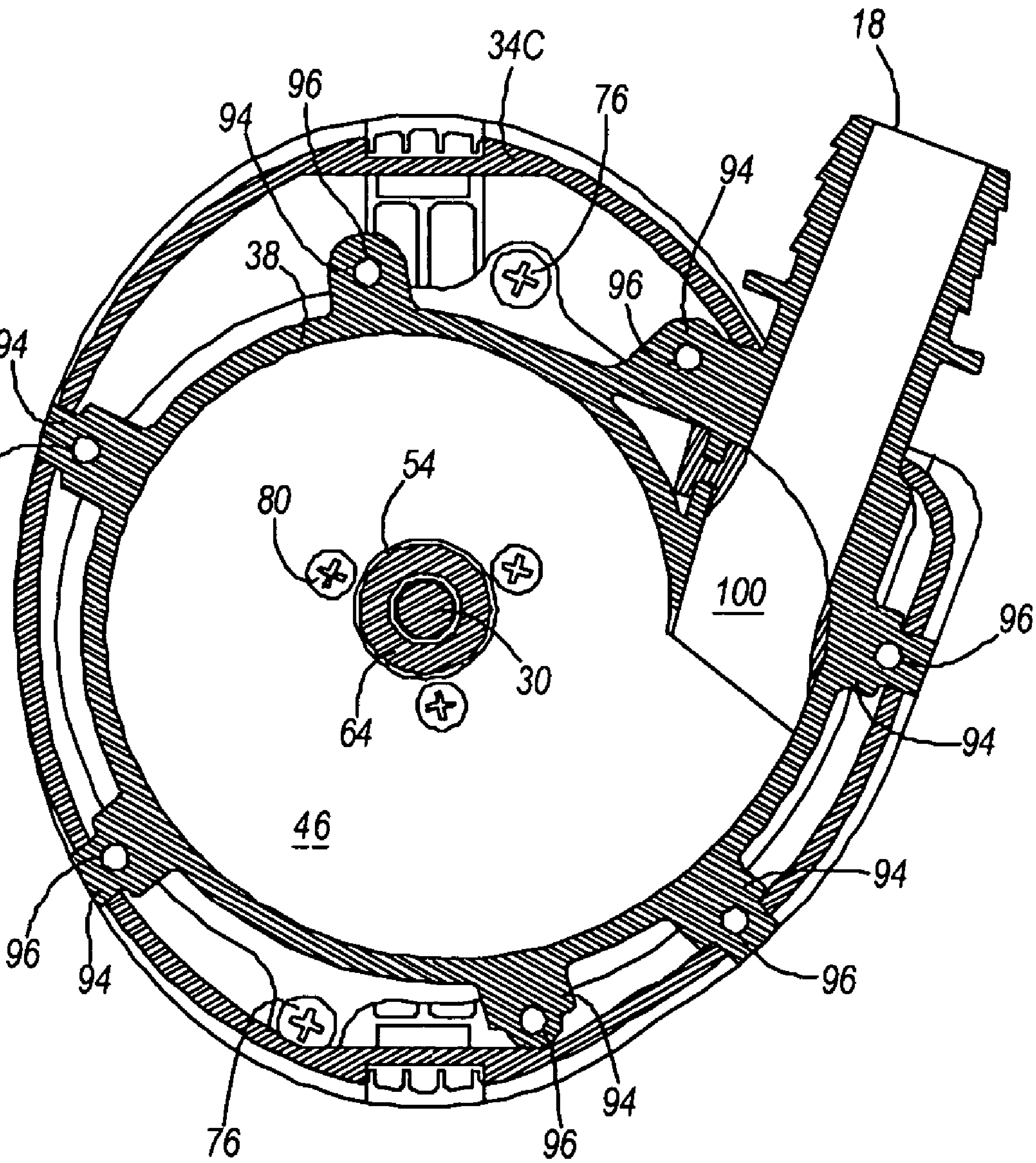
50
38
98
26B
26
42
38A
34C
26A
32
14

FIG. 4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34C
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76
94
94
38
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64
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46
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96
94

FIG. 5

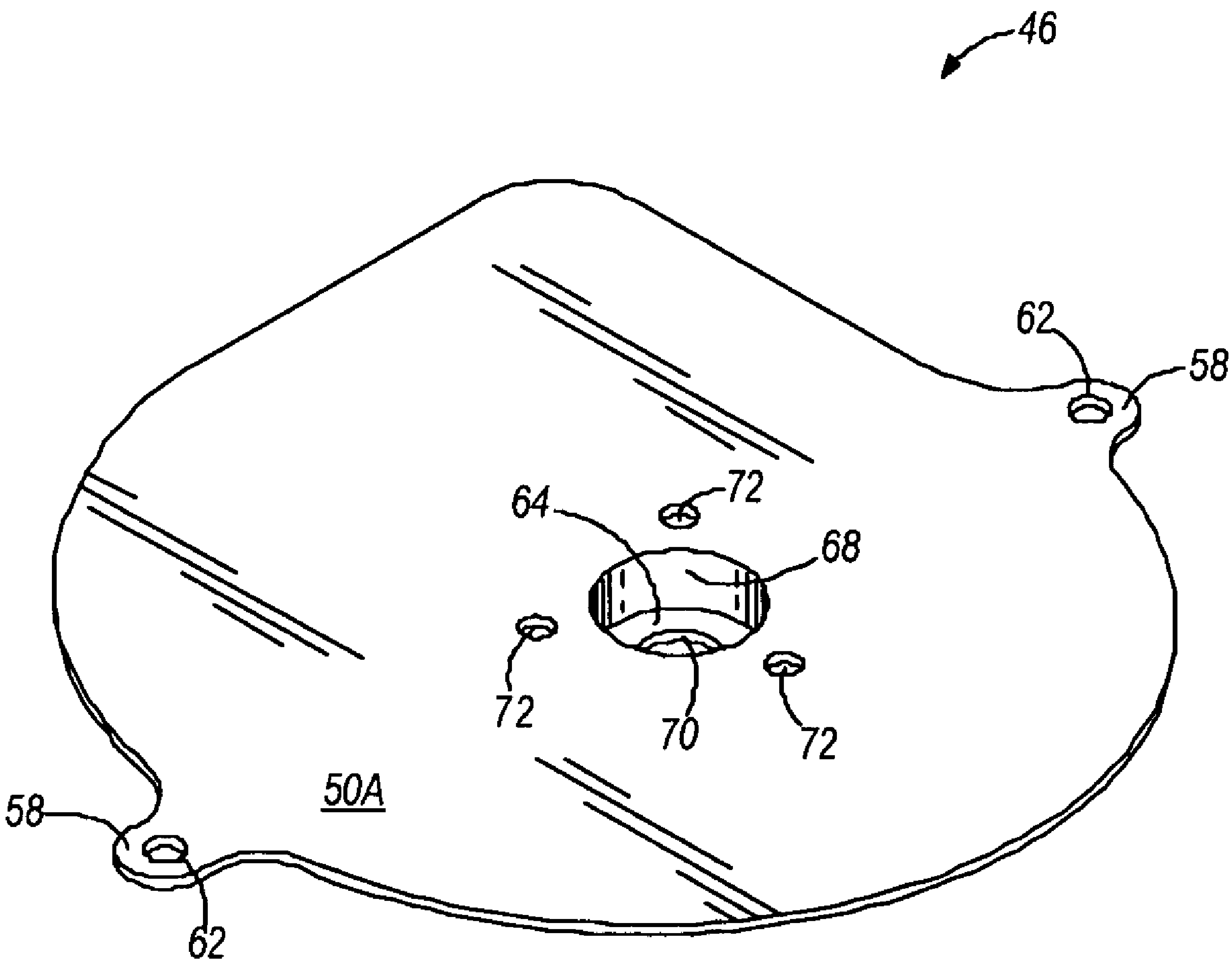

FIG. 6

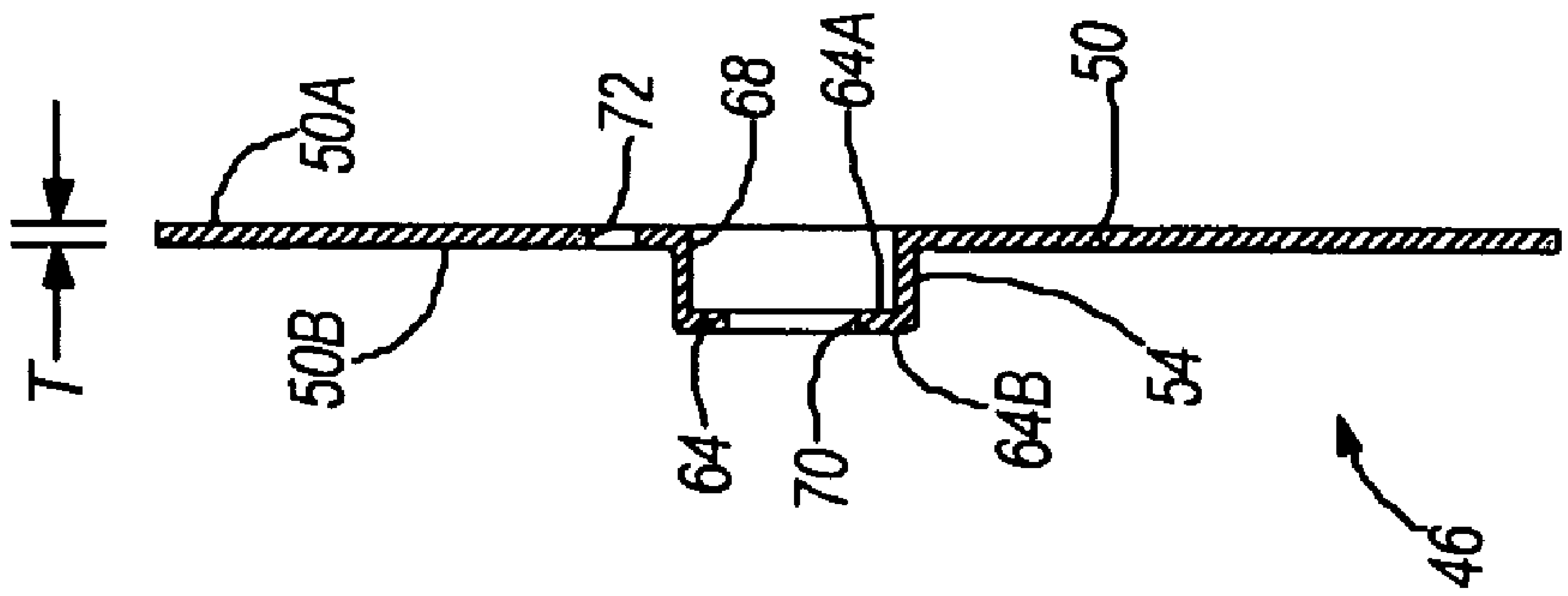

FIG. 8

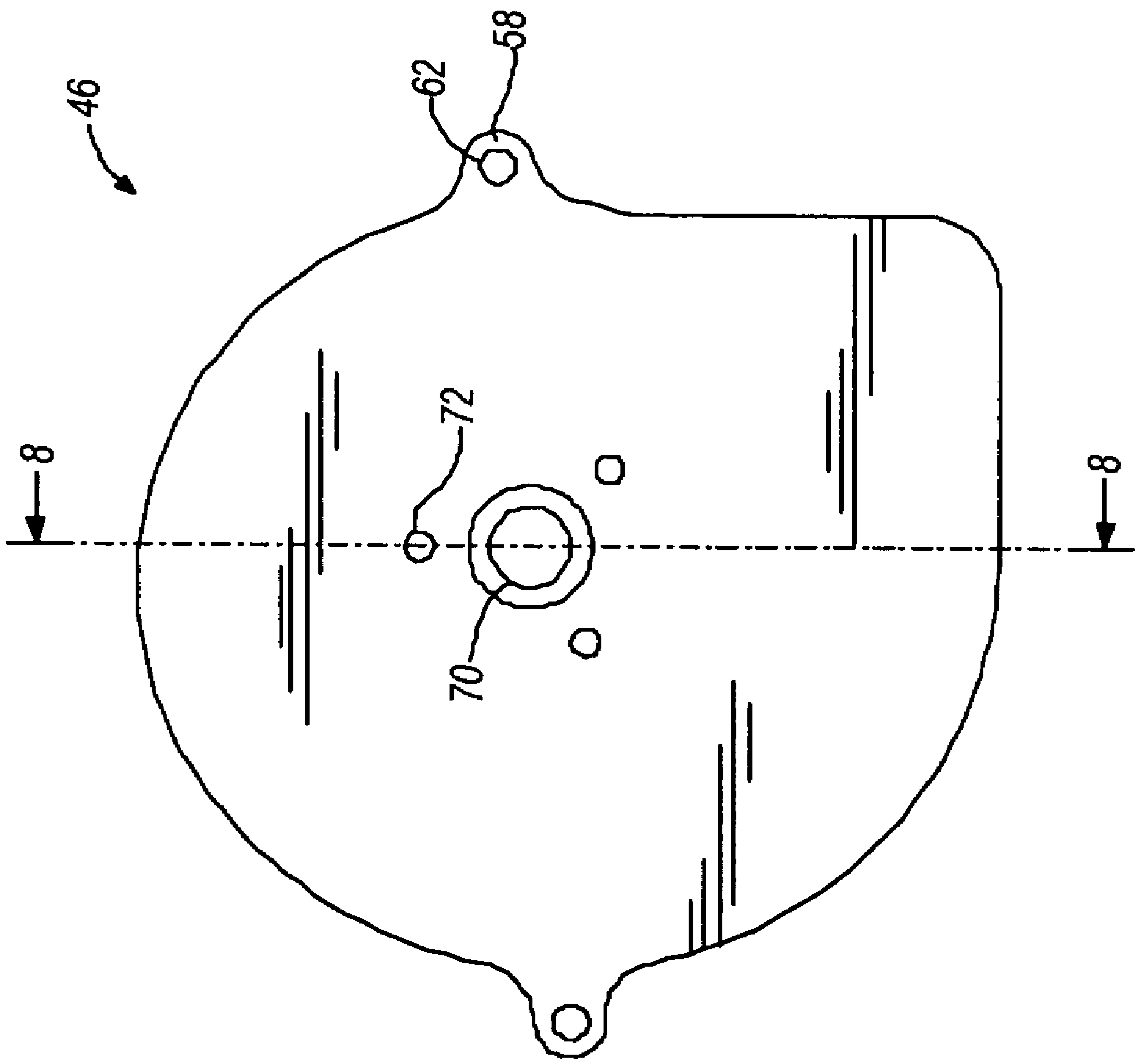

FIG. 7

PUMP APPARATUS AND METHOD

FIELD OF THE INVENTION

The invention relates to pumps, such as bilge pumps and bait/live-well pumps. More specifically, embodiments of the invention relate to cooling electric motors of pumps, particularly under high-flow or prolonged-use conditions.

BACKGROUND OF THE INVENTION

Conventional bilge and bait/live-well pumps include compact electric motors that drive an impeller and pump water from one location to another. The motors in pumps are typically permanent magnet electric motors which operate on 12 Volt, 24 Volt, or 32 Volt DC power. Upon operating at high load or over an extended period of time, pump motors produce a significant amount of heat, which can affect the efficiency of the motor or, at the extreme, damage the coils of the motor and disable it completely. Proper cooling must be taken into consideration when designing pumps.

Most commonly, bilge and bait/live-well pumps are constructed mainly of plastic, which is a good temperature insulator. This is detrimental to an electric motor that needs to dissipate heat to maintain acceptable performance. This problem has been addressed in the past by providing cooling paths within a plastic pump housing to route water directly to a portion of the motor. However, the motor contains many parts which cannot be submersed in water and must be sealed from the cooling paths, which adds cost and complexity to the design of the pump.

SUMMARY OF THE INVENTION

In one embodiment, a pump for pumping a working fluid is provided. The pump can include a pump housing defining a fluid inlet and a fluid outlet, both of which communicate with a pumping chamber. The pump can include an impeller positioned in the pumping chamber. A motor with a rotary output shaft can be coupled to the impeller. A plate at least partially constructed of a heat conductive material can at least partially define the pumping chamber. The plate can transfer heat from the motor to the working fluid in the pumping chamber.

In one embodiment, a pump can include a pump housing, a fluid inlet, a fluid outlet, a pumping chamber in fluid communication with both the fluid inlet and the fluid outlet, and a motor for pumping a working fluid. The pump can include a plate at least partially constructed of a heat conductive material. The plate can at least partially define the pumping chamber and can transfer heat from the motor to the working fluid in the pumping chamber.

In one embodiment, a method of removing heat from the motor of a pump for pumping a working fluid is provided. The method can include pumping the working fluid through a pumping chamber with a rotating impeller, conducting heat from the motor to a plate, and transferring heat from the plate to the working fluid in the pumping chamber.

Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a pump according to one embodiment of the invention;

FIG. **2** is a front view of the pump of FIG. **1**;

FIG. **3** is a side view of the pump of FIG. **1**;

FIG. **4** is a section view of the pump taken along line A-A (shown in FIG. **3**);

FIG. **5** is a section view of the pump taken along line B-B (shown in FIG. **3**);

FIG. **6** is a perspective view of a plate according to one embodiment of the invention;

FIG. **7** is a top view of the plate of FIG. **6**; and

FIG. **8** is a section view of the plate of FIG. **6** taken along line A-A (shown in FIG. **7**).

DETAILED DESCRIPTION OF THE INVENTION

Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

FIGS. **1-5** illustrate a pump **10** according to one embodiment of the invention. The pump **10** can be used as a bilge pump, a bait/live-well pump, or in other suitable environments. The working fluid pumped by the pump **10** can be fresh water, salt water, filtered water, unfiltered water, fuel, or other liquids. Bait/live-well pumps are generally continuous-duty pumps. The pump **10** can include a fluid inlet **14** and a fluid outlet **18**. The pump **10** can be powered by a motor **22**, internal to the pump **10**, which can drive an impeller **26** via a driveshaft **30**, as shown in FIG. **4**. The impeller **26** can be coupled to the driveshaft **30** by a retaining ring **32**, or can be formed integrally with the driveshaft **30** in other embodiments. The motor **22** can be a 12 Volt, 24 Volt, or 32 Volt DC motor, but DC motors of various voltages and other power sources with rotary output may also be used with the pump **10**. The pump **10** can include a housing **34**, which can be constructed of plastic and can include a generally cylindrical body **34**A, an upper cap **34**B, and a base **34**C. The base **34**C can include resilient tabs **34**D, which engage the body **34**A and mount the base **34**C to the body **34**A, as shown in FIGS. **1-3**. The motor **22** can be positioned within the body **34**A. As shown in FIGS. **1** and **3**, a wire grommet **36** coupled to the body **34**A can allow electrical wires to pass from the motor **22** to the outside of the body **34**A. As shown in FIG. **4**, an impeller shroud **38**, can surround the impeller **26**, and can define a pumping chamber. The impeller shroud **38** can include a pumping chamber inlet **38**A, which can receive working fluid from the fluid inlet **14** of the pump **10**. In some embodiments, the fluid inlet **14** of the pump **10** can be formed in the base **34**C. The fluid outlet **18** of the pump **10** can be formed as part of the impeller shroud **38** and can extend substantially tangentially from the circumference of the impeller shroud **38**.

As shown in FIG. **4**, the motor **22** can include a rotor **22**A and a magnet **22**B. The rotor **22**A can be coupled to the impeller **26**. The motor **22** can be positioned within a motor housing **22**C, which can fit with little or no clearance inside the body **34**A of the pump housing **34**. When the motor **22** is energized, the rotor **22**A can rotate relative to the magnet **22**B and motor housing **22**C about an axis running along the length and through the center of the motor housing **22**C. The impeller **26** can move fluid within the pumping chamber. The motor **22** can include bearings **22**D between the motor housing **22**C and driveshaft **30** to allow the driveshaft **30** to rotate without significant resistance and to locate and align the driveshaft **30** relative to the motor housing **22**C.

The end of the pump **10** containing the impeller **26** and the pumping chamber is referred to herein as the “lower end.” The use of the words “lower,” “upper,” “above,” “below,” etc., in the detailed description is used for reference only and should not be considered limiting. The lower bearing **22**D can be accompanied by shaft seals **42** surrounding the driveshaft **30** and positioned between the impeller **26** and the lower bearing **22**D. In some embodiments, multiple shaft seals **42** can be used to ensure no leakage of the working fluid from the pumping chamber into the motor housing **22**C along the driveshaft **30**. Many types of shaft seals in any suitable quantity can be used.

As shown in FIGS. **5**-**8**, the plate **46** can include a planar portion **50** and a boss **54** extending from the planar portion **50**. The planar portion **50** can include two mounting ears **58**, each having a mounting hole **62** for mounting the plate within the pump **10**. The planar portion **50** can have a uniform or varying thickness T between an upper surface **50**A and a lower surface **50**B. The boss **54** can be cylindrical in shape and can extend from the planar portion **50**, terminating at a recessed wall **64**, which can lie substantially parallel with the planar portion **50**. The recessed wall **64** can include an upper surface **64**A and a lower surface **64**B, where the upper surface **64**A is internal to the boss **54**, which can be hollow. The interior of the boss **54** can also include a seal retaining bore **68** having a cylindrical inner surface and forming a retaining bore. The cylindrical shape of the seal retaining bore **68** can correspond to the cylindrical shape of the boss **54**. The boss **54** and the seal retaining bore **68** can also be constructed in different shapes. In one embodiment, three mounting holes **72** in the planar portion **50** can allow the plate **46** to be coupled to the motor **22**. A bore **70** through the recessed wall **64** can allow the driveshaft **30** to pass through the plate **46**.

As shown in FIG. **4**, the lower shaft seal **42** can be encased by the seal retaining bore **68** of the plate **46**. The plate **46** can be positioned between the body **34**A and the impeller shroud **38** and can be held in place by fasteners **76**, which can pass through the mounting holes **62**. The motor **22** can be mounted to the plate **46** via fasteners **80**, which can pass from the lower surface **50**B of the planar portion **50** into threaded bores in the motor housing **22**C, aligned with the mounting holes **72**. The fasteners **76** and **80** can attach the plate **46** to the body **34**A and the motor housing **22**C, respectively, to secure the motor **22** within the body **34**A. O-rings **84**, **88** can be positioned between the plate **46** and the motor housing **22**C and the body **34**A, respectively. The O-rings **84**, **88** can prevent the working fluid from entering the body **34**A when the pump **10** is submersed. A gasket **92** can be positioned between the plate **46** and the impeller shroud **38** to create a sealed periphery around the impeller shroud **38**. The gasket **92** can prevent flow of the working fluid into or out of the pumping chamber, except at the fluid outlet **18** and the pumping chamber inlet **38**A.

FIG. **5** is a section view of the pump **10** through the recessed wall **64** of the plate **46**, along line B-B of FIG. **3**. The impeller shroud **38** can include mounting ears **94** and mounting holes **96**, which can be aligned with corresponding threaded bores in the body **34**A. Screws **98** can secure the impeller shroud **38** to the body **34**A. A flow director **100** can be positioned between the impeller shroud **38** and the plate **46** to direct flow from the pumping chamber to the fluid outlet **18**.

During operation, the motor **22** can drive the driveshaft **30** and the impeller **26**. The pump **10** can be partially submersed in working fluid. As the impeller **26** rotates, the impeller **26** creates a pressure differential, drawing working fluid into the pumping chamber through the pumping chamber inlet **38**A and forcing working fluid out of the fluid outlet **18**. The motor **22** generates heat as it operates. Heat generation is due at least partially to the electric current in the motor **22** and the small amount of friction present in the bearings **22**D and shaft seals **42**. Heat generation may be influenced by any of the following: rotational speed of the driveshaft **30**, torque load on the motor **22** due to friction (including that present between the working fluid and the impeller **26**), and time of continuous operation.

The planar portion **50** of the plate **46** can provide a large amount of surface area that thermally connects the motor housing **22**C to the working fluid within the pumping chamber. This creates a heat dissipation circuit, in which heat energy is conducted from the motor housing **22**C through the plate **46** and then conveyed to the working fluid by forced convection. In one embodiment, the plate **46** can be constructed to minimize the thickness T of the planar portion **50** to provide minimum resistance to heat conduction without sacrificing the strength necessary to mount the motor **22** in a stable manner within the pump **10**. In one embodiment, the plate **46** can be constructed of stainless steel, where the thickness T is about 0.05 inches to provide the balance between strength and the conduction heat coefficient through the thickness T. Stainless steel has suitable corrosion resistance characteristics (especially those grades in the 300 series), which is often a factor when substantially unfiltered salt water is the working fluid in the pump. In some embodiments, copper or other heat conductive metals or metal alloys can be used for the material of the plate **46**. In one embodiment, the plate **46** has about a 3 inch diameter. The diameter of the plate **46** can correspond to the size of the motor **22**. For example, a 1 inch motor can be coupled to a 1 inch diameter plate **46**. The diameter of the plate **46** can increase or decrease generally according to the size of the motor **22**.

In some embodiments, the impeller **26** can be constructed with a planar upper portion **26**A (transverse to the driveshaft **30**) and impeller blades **26**B, which can extend down from the planar upper portion **26**A. As opposed to impeller blades which extend directly from a driveshaft, the impeller blades **26**B can provide more concentrated pumping action in a radially outward direction. The planar upper portion **26**A can limit stray pumping action in the longitudinal direction (parallel to driveshaft **30**), and consequently, can affect the flow characteristics of the working fluid above the planar upper portion **26**A. In some embodiments, the pump **10** is a high flow pump, and the planar upper portion **26**A of the impeller **26** affords greater heat transfer capacity between the working fluid and the plate **46** by increasing the convection heat transfer coefficient. In some embodiments, the impeller **26** creates turbulent flow to increase the heat transfer capacity between the working fluid and the plate **46**. In some embodiments, the impeller **26** does not include a planar upper portion **26**A.

Thus, the invention provides, among other things, a pump with simple, effective cooling means for the internal motor. Various features and advantages of the invention are set forth in the following claims.

The invention claimed is:

1. A pump for pumping a working fluid, the pump comprising:

a pump housing defining a fluid inlet and a fluid outlet, the fluid inlet and the fluid outlet communicating with a pumping chamber;

an impeller positioned within the pumping chamber;

a motor with a rotary output shaft coupled to the impeller, the motor positioned within a motor chamber that is sealed from the working fluid in the pumping chamber; and

a plate at least partially constructed of a heat conductive material, the plate at least partially defining the pumping chamber, the plate transferring heat from the motor to the working fluid in the pumping chamber, the plate forming at least part of a fluid tight seal between the motor chamber and the pumping chamber.

2. The pump of claim **1**, wherein the plate is constructed of at least one of stainless steel and copper.

3. The pump of claim **1**, wherein the pump housing is constructed of plastic.

4. The pump of claim **1**, wherein the impeller is constructed of plastic.

5. The pump of claim **1**, wherein the impeller includes a substantially planar upper portion transverse to the output shaft, the substantially planar upper portion having a plurality of downwardly extending impeller blades.

6. The pump of claim **5**, wherein the impeller induces turbulence to provide an increased convection heat transfer coefficient between the working fluid and the plate.

7. The pump of claim **1**, wherein the plate has a thickness of about 0.05 inches.

8. The pump of claim **1**, wherein the pump housing includes a removable base portion having a plurality of openings defining the fluid inlet.

9. The pump of claim **1**, wherein the pumping chamber is at least partially defined by an impeller shroud.

10. The pump of claim **9**, wherein the impeller shroud includes a tubular portion defining the fluid outlet.

11. The pump of claim **9**, wherein the impeller shroud is coupled to one of the pump housing and the plate, the impeller shroud including at least one pumping chamber inlet.

12. The pump of claim **9**, wherein the impeller shroud is constructed of plastic.

13. The pump of claim **10**, wherein the fluid outlet extends from the impeller shroud substantially tangentially to the impeller.

14. The pump of claim **9**, wherein a gasket is coupled between the impeller shroud and the plate.

15. The pump of claim **1**, wherein the plate is a motor mounting plate, the plate coupling the motor to the pump housing.

16. The pump of claim **15**, wherein the motor is coupled to the plate at a central portion of the plate and the plate is coupled to the pump housing at a peripheral portion of the plate.

17. The pump of claim **1**, wherein the plate includes a seal retaining bore and a driveshaft bore, the seal retaining bore retaining a shaft seal on the rotary output shaft, the rotary output shaft passing through the driveshaft bore in the plate.

18. A heat conductive device for use in a pump including a pump housing, a fluid inlet, a fluid outlet, a pumping chamber in fluid communication with both the fluid inlet and the fluid outlet, and a motor for pumping a working fluid, the motor positioned within a motor chamber that is sealed from the working fluid in the pumping chamber, the heat conductive device comprising:

a plate at least partially constructed of a heat conductive material,

the plate at least partially defining the pumping chamber,

the plate transferring heat from the motor to the working fluid in the pumping chamber,

the plate forming at least part of a fluid tight seal between the motor chamber and the pumping chamber.

19. The pump of claim **18**, wherein the motor is an electric motor.

20. The pump of claim **19**, wherein the electric motor is one of a 12 Volt, 24 Volt, and 32 Volt direct current motor.

21. The pump of claim **18**, further comprising an impeller coupled to a driveshaft of the motor.

22. The pump of claim **18**, wherein the plate is at least partially constructed of at least one of stainless steel and copper.

23. The pump of claim **22**, wherein the plate has a thickness of about 0.05 inches.

24. The pump of claim **18**, further comprising an impeller shroud at least partially defining the pumping chamber, the impeller shroud including a pumping chamber inlet and a pumping chamber outlet.

25. The pump of claim **18**, wherein the pump housing includes a removable base portion having a plurality of openings defining the fluid inlet.

26. The pump of claim **18**, wherein the plate is a motor mounting plate, the plate coupling the motor to the pump housing.

27. A method of removing heat from a motor in a pump for pumping a working fluid, the method comprising:

pumping the working fluid through a pumping chamber with a rotating impeller;

forming a fluid tight seal with at least part of a plate positioned between a motor chamber including the motor and the pumping chamber including the working fluid;

conducting heat from the motor to the plate; and

transferring heat from the plate to the working fluid in the pumping chamber.

28. The method of claim **27**, wherein the plate couples the motor to a pump housing.

29. The method of claim **27**, wherein the plate at least partially defines the pumping chamber and the plate transfers heat to the working fluid by forced convection of the working fluid.

30. The method of claim **29**, wherein the impeller induces turbulence within the pumping chamber which increases the convection heat transfer coefficient between the working fluid and the plate.

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